Video signal processing

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for video signal processing. Also, the present invention relates to a display apparatus comprising such a video signal processing apparatus.

BACKGROUND OF THE INVENTION

In one example form of video signal processing, a noise reduction function is applied to reduce noise in a video signal. Noise reduction processing can be applied in a sequential order, first to a luminance component of the video signal, and then to chrominance components of the video signal. Conveniently, the same noise reduction circuit is used for both the luminance and chrominance components of the video signal. Optionally, in luminance controlled processing, a control signal is derived from the luminance component and written to a background memory during processing of the luminance component, and read from the background memory for use during the subsequent processing of the chrominance components. This luminance-derived control signal can also be used in other forms of video signal processing. A problem arises in that storage of the control signal involves a relatively large quantity of data. For example, in a typical prior art system the luminance-derived noise reduction control signal has a quantization of seven bits, such that one byte of data storage is required for each pixel in the video signal.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved video signal processing. To this end, the invention provides a method and apparatus for compression of a luminance-derived control signal wherein the quantity of data is reduced. It is a further aspect of the present invention to provide a method and apparatus for video signal processing,

wherein a luminance-derived control signal is compressed. The invention is defined in the independent claims. Advantageous embodiments are defined in the dependent claims.

According to a first aspect of the present invention there is provided a method and device for compression of a luminance-derived control signal for use in a video signal processing circuit, comprising quantizing the luminance-derived control signal using a non-linear compression function.

Preferably, the method is for use in a video signal noise reduction circuit. Preferably, the quantized luminance-derived control signal produces a substantially linear perceptual change in a noise reduction factor of the noise reduction circuit. Preferably, the non-linear compression function is applied such that any one-step difference in the quantization level of the luminance-derived control signal produces a substantially constant perceptual step change in a noise reduction factor of the noise reduction circuit. Preferably, the non-linear compression function is applied such that any one-step change in the luminance-derived control signal between quantization levels produces a substantially equal change in the noise reduction factor of the noise reduction circuit, when expressed in dB. For example, it is desired that a step change in the noise reduction factor differs by no greater than about 50%, preferably no greater than about 25% and ideally no greater than about 10%. That is, the magnitude of the largest and smallest step changes preferably differ by no more than about 10%.

Preferably, the non-linear compression function is determined by the steps of (a) determining a desired range of noise reduction factors to be applied by a noise reduction circuit; (b) dividing the range into a predetermined number of substantially equal steps, and (c) calculating a set of values of a luminance-derived control signal appropriate to each step as a set of quantization threshold values. By experience, a noise reduction factor range of zero to about 12 dB has been found to be particularly acceptable, given the properties of the human visual system. Suitably, the range is divided into 16 discrete steps, such that the luminance-derived control signal is conveniently quantized to 4 bits. However, any suitable range and any suitable number of steps may be chosen.

Preferably, the method also comprises the step of averaging the luminance-derived control signal over a predetermined pixel area. The luminance-derived control signal represents the amount of temporal changes in the video signal at the current image position at high detail level. Advantageously, it has been found that the human visual system has a relatively low sensitivity to the level of detail in the chrominance components of the video signal, compared with sensitivity to detail in the luminance component. Therefore, the

sequential chrominance processing. The output signal of the noise filter 30 is displayed on a display 40.

A preferred video signal processing method comprises, a step of deriving a control signal k_lum from the luminance component, a step of controlling a noise reduction function applied to the luminance component, a step of storing the control signal, and a step of controlling a noise reduction function applied to the chrominance components. The method also includes a step of compressing the luminance-derived control signal such that the quantity of data to be stored is reduced. The compression step will now be described in more detail.

The control signal k_lum is preferably derived for each pixel of an image in the video signal such that a full control is available when signal processing the luminance component. However, the control signal is compressed prior to storage to reduce the quantity of data to be stored. A first compression step comprises averaging the control signal k_lum over a predetermined pixel area. In the preferred embodiment the control signal is averaged over 2x2 luminance pixels (i.e. 2 pixels in one row and 2 pixels in the next row). This preferred embodiment assumes a 4:2:2 YUV color format. However, any suitable pixel area can be chosen. The second compression step comprises applying a non-linear compression function to the averaged control signal.

Typically, the not yet compressed control signal k_lum has a quantization of 7 bits, in order to provide granularity of control appropriate to the perceptual qualities of the human visual system. However, it is most convenient to store data in the background memory in either 4 bits or 8 bits. The standard 7 bit quantization of the control signal k_lum therefore requires 1 byte of data per pixel. One option is to reduce the quantization of the control signal k_lum to, for example, use 4 bits. Unfortunately, a linear quantization to 4 bits has been found to be insufficient for a smooth fading for the recursive noise reduction filter function. To illustrate, an analysis can be done by calculating the noise reduction factor (NRF) dependent on the control signal k. The NRF for a recursive loop of first order can be calculated to:

$$NRF = 10 \bullet \log\left(\frac{2}{k} - 1\right)[dB] \qquad (1)$$

The NRF is preferably quoted in dB to give a more proportional perception of the human visual system. Taking a 4-bit quantized control signal k, the noise reduction factor at each quantization level can be calculated as set forth in table 1 below.

Table 1

control signal (k)	**NRF [dB]**
1	0
15/16	0.54
14/16	1.1
13/16	1.6
12/16	2.2
11/16	2.8
10/16	3.4
9/16	4.1
8/16	4.8
7/16	5.5
6/16	6.4
5/16	7.3
4/16	8.5
3/16	9.9
2/16	11.8
1/16	14.9

As shown in Table 1, the linear quantized k-values cause a non-linear behaviour of the noise reduction factor. At high k-values there is a relatively small change in the noise reduction factor between levels. For example, the difference from 1 to 15/16 results in a noise reduction difference of 0.54 dB. However, at low k-values there is a large change in the NRF. For example, the difference from 2/16 to 1/16 results in a noise reduction difference of 3.1 dB. Especially for high noise reduction factors, switching between two levels can cause unwanted additional artefacts. That is, a change in noise reduction factor of the order of 3dB results in poor visual perception of the noise-filtered image.

We will now describe a preferred method for determining a non-linear compression function applied to the control signal. The first step comprises determining a

desired range of the noise reduction factor. By experience, it has been found that a maximum NRF of around 12dB is sufficient. The second step comprises dividing the NRF range into substantially equal portions. In the preferred embodiment the NRF range is divided into 16 portions corresponding to a 4-bit quantization. The NRF range is divided such that the noise reduction factor follows a substantially linear behavior. With a NRF range of about 12dB, a 4-bit quantization allows for switching steps of around 0.8 dB over the entire range. By taking the reverse of Equation 1 above for the desired NRF values, the corresponding k-values can be calculated according to Equation 2:

$$k = \frac{2}{1+10^{\frac{NRF[dB]}{10}}} \quad (2)$$

The calculation of the k-values is algorithm dependent, and therefore should be calculated as the reverse of the NRF equation. Taking the preferred example situation, a 4-bit quantization over a NRF range of 12 dB leads to the k-values as set out in Table 2 below:

Table 2

NRF [dB]	**k**
0	1
0.8	0.9082
1.6	0.8178
2.4	0.7305
3.2	0.6474
4.0	0.5695
4.8	0.4975
5.6	0.4319
6.4	0.3728
7.2	0.3201
8.0	0.2736
8.8	0.2329
9.6	0.1976
10.4	0.1672
11.2	0.1410
12.0	0.1187